Analysis of Unilateral and Bilateral Strength Asymmetries of Knee Flexors and Extensors during Detraining, Competition and Transition Phases in Basketball Players

BY

DEEKSHA SINGH

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SYNOPSIS

Submitted to:

Department of Exercise Physiology

Lakshmibai National Institute of Physical Education, Gwalior

Required for the degree of Doctor of Philosophy in Physical Education

(2021)

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CHAPTER 1

INTRODUCTION

Know safety, no injury; no safety, know injury

-Anoynomous

In today's era, lifestyle has seen some significant changes mainly due to technological advancement and increasing focus on winning in all walks of life. Working for long hours while compromising sleep, lack of focus on good diet, reduction in physical exercise, shift towards ready-made unhealthy food are some key factors that are affecting health seriously. Moreover, the environmental pollution is acting as the last straw that breaks the camel's back. This is the common trend in present scenario.

Diseases like Cardiac arrest, Heart Attack, Cancer, Arthritis and the latest one with communicable characters- COVID- 19 has added insult to injury. Nonetheless, as every coin has two sides, there exists many health-conscious individuals because Newton's concept of Survival of the fittest is eternal in all forms of life. As a result, the trend of physical activities and sports never depletes. There are various ways in order to stay fit, indulging in sports is one among them. Initially, majority seeks sports for the fun that it holds, gradually it turns to one's passion and the profession. While in developed countries, sports is a full-fledged profession where children are being sent to academies, clubs and other sports organizations at an early age to produce Olympians and international sportspersons.

The heightening professionalism and increase in training goes concurrently. The motto of Olympics- Citius, Altius, Fortius explains the focus of this training rightly. It literally means Swifter, Higher, Stronger which in turn suggests towards being better than yesterday and ultimately challenging one's abilities every day. This is appropriate until one is following the principles of sports training strictly which ideally is not possible all the time. That's where the concept of injury creeps in. Notably, this excessive pressure of success and sports injuries are concurrent to each other.

The positive effects of physical activity and sports are cited everywhere in literature but the negative one's are limited and less worked upon. The malpractices indulged in sports prima facie leads to excruciating injuries and may affect an individual's growth. These malpractices are the training errors, winning at all costs, biasness in selection, doping and so on so forth.

Among the training errors there is over indulged preferred side and its training. Again, if the use of preferred side is in normal range, then it is worthy but if it crosses that limits it adds to the prone area of injury for the weaker part. There are various sports where athletes prefer a single side rather than the other such as football, hockey, basketball, badminton, judo, etc. These sports practice and the respective workout may lead to a bigger request of specific muscles groups, mainly in asymmetric sports (Cumps et al., 2008). However, this muscle specialization may result in an imbalance of the forces applied in the joint being able to expose the athletes to injuries, which bring (carries) major economic damages for the teams (Langevoort et al, 2007; Schiltz et al., 2009).

In basketball, athletes traverse substantial distances, covering around 4500–5000m during a 40-minute game, engaging in various multidirectional activities like running, dribbling, shuffling, and jumping (Crisafulli et al., 2002). However, despite its global appeal and the excitement it generates, basketball faces a significant challenge in the form of injuries, largely stemming from the physical demands placed on athletes. Basketball, as a dynamic team sport, demands precise skills and involves a range of movements that heavily rely on specific muscles, often leading to the dominance of certain muscle groups or preferred sides in players. These movements include abrupt changes in direction, rapid decelerations, and the repeated impact of landing from jumps. Thus, it is reasonable to speculate that basketball players may develop peak torque and muscular balance differently, depending on their preferred side or dominating muscle. Researchers have highlighted the significance of maintaining a balanced ratio of torque between reciprocal muscle groups for joint stability and injury prevention, particularly focusing on hamstring and quadriceps peak torque (Gerodimos et al., 2003). Consequently, the surge in sporting activity and training intensity has corresponded with a rise in sports injuries, encompassing both acute incidents and overuse trauma.

The muscular imbalances are one of the predisposing factors most cited in literature about sports injuries (Gioftsidou et al., 2008). These can be observed through the differences of strength between agonist/antagonist muscles and the bilateral differences Gioftsidou et al., 2008; Henderson et al., 2010). In knee joint, the relationship among agonist/antagonist used is the ratio Hamstrings/Quadriceps (RH/Q) (Dvir et al., 2004; Croisier et al., 2008; Kong et al., 2010; Wright et al., 2009).

Isokinetic measurement is a sophisticated and precise method for evaluating muscle strength and identifying imbalances in basketball players. Unlike traditional strength testing,

isokinetic assessments involve constant speed movements, allowing for accurate measurements of force production and muscle performance throughout the full range of motion. This method is particularly valuable in assessing both unilateral and bilateral muscle imbalances, providing objective data for targeted interventions and rehabilitation strategies. It has been shown that data obtained from isokinetic strength testing in basketball players could predict ACL injury subsequent to strength testing (Myer et al., 2009). Furthermore, isokinetic evaluation of knee extensors at 60 deg/sec may indicate knee extensors torque asymmetry which in turn may play a role in jumper's knee pathology which is one of the most common overuse injuries in basketball players (Dauty et al., 2007).

In isokinetic testing, an isokinetic dynamometer is typically used. This device maintains a consistent speed throughout the movement, ensuring uniform velocity during both concentric (muscle shortening) and eccentric (muscle lengthening) contractions. The dynamometer measures the torque produced by muscles at various joint angles, creating a detailed strength profile across the full range of motion.

For addressing muscle imbalances, isokinetic assessments can focus on specific joints, such as the knee, which is susceptible to injuries in basketball. A common test involves assessing the strength of the quadriceps and hamstrings. Imbalances between these muscle groups, especially weaker hamstrings relative to quadriceps, can increase the risk of knee injuries, including ACL tears.

One major benefit of isokinetic testing is its ability to calculate strength ratios, such as the hamstring-to-quadriceps (H/Q) ratio. The H/Q ratio for the knee joint is crucial, as noted by Croisier et al. (2008). A lower H/Q ratio can indicate an imbalance, potentially placing more stress on the knee joint and raising the risk of injuries. This ratio is essential for designing targeted strengthening programs to address specific weaknesses and prevent imbalances that could compromise athletic performance. Although there is no consensus on normative H: Q values, certain ranges are generally accepted. Values between 50-69% at 60 deg/sec and 70-80% at 180 deg/sec are recognized, according to Sonzogni and Gross (1993) and Aagaard et al. (1995). For conventional H/Q ratios, a broad range of "optimal" values (0.5-0.8) has been reported without established empirical relationships between an "optimal" H/Q value and injury prevention or rehabilitation (Kannus, 1994). The recommended ratio is 3:2 (Charles, 1999). Large concentric quadriceps forces can lead to hamstring strains, typically occurring at

the proximal origin but occasionally at the semimembranosus with discomfort along the posterior medial knee capsule.

Traditionally, the H/Q ratio is calculated as the knee flexion moment divided by the knee extension moment at the same angular velocity and contraction mode (concentric, eccentric, isometric). Thus, the conventional H/Q ratio indicates the degree of qualitative similarity between quadriceps and hamstring moment-velocity patterns, reflected in the constancy of the H/Q ratio across speeds. From a functional perspective, dynamic joint movement involves concentric agonist muscle contraction with varying degrees of eccentric antagonist contraction, or vice versa. This antagonist co-contraction is an inherent component of various joint movements (Smith, 1981), including the knee joint, where it is suggested to reduce anterior tibial shear relative to the femur (Renstrom et al., 1986; Solomonow et al., 1987). Therefore, information on the agonist-antagonist strength relationship during actual knee extension or flexion is essential. For this, an H/Q concept is introduced, which is useful in describing and evaluating dynamic knee joint stability: at a given angular velocity, this H/Q ratio is calculated as maximal eccentric hamstring strength divided by maximal concentric quadriceps strength (H/Q for knee extension) or maximal concentric hamstring strength divided by maximal eccentric quadriceps strength (H/Q for knee flexion). This functional H/Q ratio indicates potential muscle stabilization at the knee joint during actual knee extension or flexion (Aagaard et al., 1995).

The functional hamstrings to quadriceps (H) strength ratio measures the isokinetic eccentric peak torque of the hamstrings relative to the isokinetic concentric peak torque of the quadriceps during leg extension at equivalent angular velocities (Aagaard et al., 1995). The development of the functional H/Q ratio was proposed as an improved measure of the agonist: antagonist relationship between the hamstrings and quadriceps compared to the conventional H/Q ratio, which compares the concentric peak torque of the hamstrings during leg flexion to the concentric peak torque of the quadriceps during leg extension (Dvir et al., 1989; Jenkins et al., 2012). The minimal recommended H/Q_{func} increase between different tested speeds is not well-established. However, it is suggested that the optimal H/Q_{func} increase between speeds of 60 deg/sec, 180 deg/sec, and 240 deg/sec should be above 0.6, above 0.8, and above 1.0, respectively (Aagaard et al., 1995, 1998). The H/Q_{func} should also be evaluated concerning specific athlete groups, where uninjured elite sprinters tested at 60 deg/sec reported an H/Q_{func} of 0.83 ± 0.17, and injured sprinters reported 0.73 ± 0.1235 (Sugiura et al., 2008).

Bilateral imbalance, also known as asymmetry, refers to the differences between the sides of the body in terms of muscular performance or function (Jones & Bampouras, 2010). These imbalances can be influenced by factors such as gender, training age, pre-existing injuries, sports demands, and anthropometric variables (Cane et al., 2008; Fousekis et al., 2010; Hägglund & Waldén, 2016). Assessing an individual's asymmetry can help identify potential injury markers (De Britto et al., 2015; Xaverova et al., 2015), individual strength imbalances (Hewit et al., 2012), limb dominance (Dos'Santos et al., 2017), and motor skill synchronicity (Vieira et al., 2016). Bilateral strength imbalances are often evaluated by comparing sidedness (Newton et al., 2006), limb preference (Capranica et al., 1992; Samadi et al., 2009; Valdez, 2003), and limb dominance (Daneshjoo et al., 2013; Dos'Santos et al., 2018; Sugiyama et al., 2014), using both cyclic and acyclic measures, such as unilateral jump performance (De Britto et al., 2015; Lockie et al., 2014), isokinetic dynamometry (Jones & Bampouras, 2010; Petschnig, Baron, & Albrecht, 1998), and change of direction tasks (Dos'Santos et al., 2017, 2018). These tests employ various metrics, including force, time, and velocity, to measure asymmetry, ultimately comparing percentage differences between limbs when evaluating sidedness, preference, and dominance (Newton et al., 2006). Although each method is widely used to measure imbalances, the terms are fundamentally different (Sadeghi et al., 2000), necessitating a like-for-like comparison between methods. Isokinetic assessments also facilitate the evaluation of both dominant and non-dominant limbs, providing a comprehensive understanding of strength discrepancies. Identifying muscle strength disparities between the right and left sides is essential for developing personalized training programs that address specific weaknesses and restore symmetry. Furthermore, isokinetic testing establishes a baseline for monitoring progress over time, allowing for adjustments to training protocols based on individual needs and ensuring ongoing muscular balance.

Some scholars propose that bilateral differences (BD) exceeding 10 to 15% are considered significant asymmetries, with larger deficits potentially indicating muscular imbalances (Coombs & Garbutt, 2002; Dauty et al., 2007; O'Sullivan et al., 2008). Various team sports (Hart et al., 2014; Menzel et al., 2013) and rehabilitation literature (Clark, 2001; Petschnig et al., 1998) have adopted this 15% asymmetry index as an indicator of potential injury and rehabilitation protocol success. A bilateral strength difference over 20% suggests a predisposition to injury (Fowler et al., 1993). Conversely, a bilateral deficit less than 10% is not considered a significant imbalance and is seen as a target for athletes recovering from previous imbalances or reconditioning after injury (Dauty et al., 2003). Despite ongoing debate,

the inherent asymmetry in certain activities underscores the utility of comparing bilateral strength as an effective indicator of potential muscular system deficits.

When investigating sport-specific asymmetries, such as those observed in basketball players, it is crucial to understand the nature of the motor skills performed, the performance velocities of the movements, and the population under investigation. Basketball is a sport with an increased risk of lower limb injuries because players often favor one side, potentially leading to sport-specific imbalances. Additionally, females and those with lower professional training age are more likely to display problematic asymmetry characteristics (Bailey et al., 2015; Fousekis et al., 2010; Pappas & Carpes, 2012). This is attributed to factors such as inconsistent movement patterns, hip valgus, and muscular strength deficits (Bailey et al., 2015; Fousekis et al., 2010). Early identification of asymmetries allows for corrective training interventions to enhance long-term performance and participation (Standing et al., 2022).

Isokinetic measurement stands out as a sophisticated tool for the precise assessment of muscle imbalances in basketball players. By offering detailed information on strength profiles, bilateral comparisons, and specific muscle ratios, isokinetic assessments contribute to the development of targeted training interventions. This approach plays a pivotal role in injury prevention and rehabilitation, helping athletes achieve optimal performance while minimizing the risk of musculoskeletal issues.

In summary, the advantages of using isokinetic measurement for knee imbalances assessment lie in its precision, objectivity, dynamic nature, and the ability to provide valuable insights for injury prevention and rehabilitation. It is a valuable tool for healthcare professionals working with athletes, especially those involved in sports with high demands on the knee joint like basketball. (Mendoza & Miller, 2014) Isokinetic measurement offers several advantages in research, particularly in the realm of sports science and biomechanics. One notable advantage lies in its ability to provide precise and standardized assessments of muscle strength across various joints and movement patterns. Unlike isotonic or isometric measurements, isokinetic testing ensures that the muscle contracts at a constant speed throughout the range of motion, allowing for accurate quantification of strength capabilities (Perrin, 1993). Additionally, isokinetic devices often incorporate gravity correction mechanisms, which compensate for the effects of gravitational forces, thereby enabling more accurate measurement of muscle forces irrespective of the orientation of the body or the testing apparatus. This feature enhances the reliability and validity of the results, crucial for rigorous

scientific investigation (Abernethy et al., 2005). Furthermore, the versatility of isokinetic systems allows researchers to customize testing protocols to match sport-specific requirements, including the option to adjust velocity settings to mimic the dynamic demands of particular athletic activities. By adapting the testing parameters to specific sports or movements, researchers can obtain insights into the functional capacities of athletes, identify areas for improvement, and develop targeted training interventions. Overall, the incorporation of gravity correction and the flexibility to select sport-specific velocities enhance the utility and effectiveness of isokinetic measurement in advancing our understanding of human performance and optimizing athletic training strategies (Mendoza & Miller, 2014).

According to the NCAA, the rate of ACL injuries in women basketball players is at least three times higher than in men. Athletic trainers and sports medicine professionals often cite hamstring strength and H: Q ratios as significant factors (Smith & Johnson, 2022). To understand these sex differences better, it is crucial to have normative strength data for hamstrings and quadriceps, which can aid in designing effective injury prevention and basketball-specific conditioning programs.

There is a notable scarcity of studies specifically including female basketball players in isokinetic assessments, highlighting a significant research gap. Addressing this gap could provide insights into the physiological characteristics and performance profiles of female basketball athletes, impacting training protocols, injury prevention, and performance optimization.

An important issue in muscle strength assessment that is consistently overlooked is the effect of body size. Most studies present strength data either non-normalized for body size or use inappropriate normalization methods. Few studies consider the effect of body size on the muscular strength of basketball players, despite significant differences in body size among playing positions (Ostojic et al., 2006; Sallet et al., 2005). Body size has a significant positive relationship with muscular strength (Bradic et al., 2009; Jaric, 2002; Jaric et al., 2005; Markovic & Jaric, 2007).

Accurately correcting for gravity effects is crucial in isokinetic dynamometry, particularly for knee extensors and flexors. Gravity impacts recorded torque values, leading to overestimation of active flexor torque and underestimation of extensor torque (Winter et al., 1981). Implementing gravity correction enhances the validity of muscle performance assessments, especially in clinical settings and research applications.

Performance testing is often used to assess offseason training status, player selection, and the effectiveness of training programs (Gil et al., 2007; Lago-Penas et al., 2011; Miller et al., 2011; Wong et al., 2009). However, less is known about using muscle strength or agonist: antagonist ratios to profile the elite status of basketball athletes. The functional H: Q ratio offers an improved measure of the agonist-antagonist relationship (Dvir et al., 1989), yet comprehensive approaches are less prevalent in basketball research.

Exploring contralateral deficit is important for athletes who perform tasks like jumping on one leg, which can develop asymmetry between limbs (Abad et al., 2022; Kalata et al., 2020). No previous studies have analyzed the effect of long-term training programs involving different phases on isokinetic strength using 60 deg/sec, 120 deg/sec, and 180 deg/sec angular velocities at two contraction modes in collegiate basketball players. Research on the long-term detraining effects on muscular performance in basketball players is also scarce. While some technical actions in sports are performed at higher speeds, the literature suggests that using velocities greater than 180 deg/sec is questionable, as contractions at these speeds are not purely isokinetic, and the acceleration and deceleration phases occupy most of the motion range (Berry & Dvir, 1995). Therefore, this study confines assessments to speeds of 60 deg/sec, 120 deg/sec, and 180 deg/sec during isokinetic evaluation.

Comparing existing data is challenging due to variations in study procedures, including testing speeds, normalization for body mass, and gravity adjustments, as well as a lack of information on injury history and strength training. Different isokinetic evaluation protocols, equipment, and stabilizing methods further complicate comparisons. There is a lack of consensus in the studies, particularly regarding hamstrings and quadriceps strength data for basketball athletes. This is concerning given the sport's popularity and the higher risk of ACL injuries in female players.

The dominance of the dominant limb over the non-dominant limb is also a controversial subject, with mixed findings across different sports. Many studies have focused on professional athletes, with less research on collegiate athletes, and have not addressed the history of knee injuries.

These research gaps underscore the need for standardized protocols and comprehensive studies to improve our understanding of performance optimization, injury prevention, and training specificity in basketball athletes.

STATEMENT OF PROBLEM

The purpose of this study is to assess the unilateral and bilateral muscle strength asymmetries in the knee flexors and extensors of basketball athletes during detraining, competition and transition phases through the isokinetic analysis of peak torque values of flexors and extensors of left and right knees at varying speeds.

OBJECTIVES OF STUDY

For assessment of unilateral and bilateral muscle strength asymmetries through isokinetic evaluation, the following objectives have been framed:

- To evaluate the peak torque values of knee flexors and extensors at different velocities during detraining, competition and transition phases.
- To evaluate the peak torque to body weight ratios of knee flexors and extensors at different velocities during detraining, competition and transition phases.
- To evaluate the unilateral conventional peak torque ratios of knee flexors and extensors at different velocities during detraining, competition and transition phases.
- To evaluate the unilateral functional peak torque ratios of knee flexors and extensors at different velocities during detraining, competition and transition phases.
- To evaluate the bilateral peak torque asymmetry of knee flexors and extensors at different velocities during detraining, competition and transition phases.

RESEARCH QUESTIONS

The purpose of this research is to answer the following questions:

- Is there any significant difference in the unilateral conventional peak toque ratio of male and female subjects at different velocities and in different phases?
- Is there any significant difference in the unilateral conventional peak torque ratios among detraining, competition and transition phases at different velocities?
- Is there any significant difference in the unilateral conventional peak torque ratios among 60 deg/sec, 120 deg/sec, and 180 deg/sec velocities during detraining, competition and transition phases?

- Is there any significant difference in the unilateral functional ratio of male and female subjects at different velocities and in different phases?
- Is there any significant difference in the unilateral functional peak torque ratios among detraining, competition and transition phases at different velocities?
- Is there any significant difference in the unilateral functional peak torque ratios among 60 deg/sec, 120 deg/sec, and 180 deg/sec velocities during detraining, competition and transition phases?
- Is there any significant difference in the bilateral asymmetry between male and female subjects at different velocities and in different phases?
- Is there any significant difference in the bilateral asymmetry among detraining, competition and transition phases at different velocities?
- Is there any significant difference in the bilateral asymmetry among 60 deg/sec, 120 deg/sec, and 180 deg/sec velocities during detraining, competition and transition phases?

DELIMITATIONS

Following is considered as delimitations of study:

1. The study is delimited to twenty-four (n=24) basketball players of Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh.
2. Further, the study is restricted to participants of age ranging between 18-28 years.
3. The study is bound to the peak torque values of isokinetic strength.
4. The study is confined to the following movements:
    - Knee Extensors
    - Knee Flexors
5. The study is restricted to conventional unilateral ratio, functional unilateral ratio, and bilateral asymmetry.
6. The study is confined to the assessment speeds of 60 deg/sec., 120 deg/sec., and 180 deg/sec during isokinetic evaluation.
7. The study is bound to detraining, competition and transition phases.

HYPOTHESIS

On the basis of review of related literature and discussion with experts:

- It is hypothesized that there would be significant differences in the unilateral conventional peak toque ratio of male and female subjects at different velocities and in different phases.
- It is hypothesized that there would be significant differences in the unilateral conventional peak torque ratios among detraining, competition and transition phases at different velocities.
- It is hypothesized that there would be significant differences in the unilateral conventional peak torque ratios among 60 deg/sec, 120 deg/sec, and 180 deg/sec velocities during detraining, competition and transition phases.
- It is hypothesized that there would be significant differences in the unilateral functional ratio of male and female subjects at different velocities and in different phases.
- It is hypothesized that there would be significant differences in the unilateral functional peak torque ratios among detraining, competition and transition phases at different velocities.
- It is hypothesized that there would be significant differences in the unilateral functional peak torque ratios among 60 deg/sec, 120 deg/sec, and 180 deg/sec velocities during detraining, competition and transition phases.
- It is hypothesized that there would be significant differences in the bilateral asymmetry between male and female subjects at different velocities and in different phases.
- It is hypothesized that there would be significant differences in the bilateral asymmetry among detraining, competition and transition phases at different velocities.
- It is hypothesized that there would be significant differences in the bilateral asymmetry among 60, 120, and 180 degrees per second velocities during detraining, competition and transition phases.

DEFINITION AND EXPLANATION OF TERMS

- **ISOKINETIC ASSESSMENT**: Isokinetic exercise devices involve speed-controlled movements as the patient accelerates a lever arm to a predetermined maximal velocity and then moves through a range of motion and decelerates at the end of the range to the terminal position. (Malone, 2009)

  Isokinetic exercise, or accommodating variable-resistance exercise, is performed at a fixed speed with the resistance matching the muscle force at that speed of movement. (Dale, 2012)
- **PEAK TORQUE**: Peak torque (PT), refers to the single highest torque output of the joint produced by muscular contraction as the limb moves through the range of motion. (Kannus, 1994)
- **ANGLE OF PEAK TORQUE**: This is defined as the flexion or extension angle at which peak torque occurs. (Yosmaoğlu et al., 2017)
- **KNEE FLEXORS**: The muscles which help to flex the knee, it includes the set of hamstrings, gracilis, sartorius, gastrocnemius, plantaris, and popliteus. (Mansfield & Neumann, 2019)
- **KNEE EXTENSORS**: The muscles which helps to extend the knee. The four extensors of the knee are known collectively as the quadriceps femoris muscle. The muscles are rectus femoris, vastusintermedius, vastuslateralis and vastusmedialis. (Monte & Franchi, 2023)
- **DETRAINING PHASE**- A partial or complete loss of training induced anatomical, physiological and performance adaptations, as a consequence of training reduction or cessation. (Bosquet & Mujika, 2012)
- **COMPETITION PHASE**: The competition phase in sports refers to the period during which athletes participate in official competitions and events, aiming to achieve peak performance and successful outcomes. This phase is characterized by a focus on specific tactical and technical skills, psychological preparation, and optimal physical conditioning tailored to the demands of the competition. The objective during this phase is to apply the training and strategies developed in the preparatory phase to real competitive scenarios.

  According to Bompa and Haff (2009), the competition phase "involves the application of skills and techniques that have been developed and refined during the preparation phase. This phase requires careful management of training loads to ensure

athletes peak at the right time, maintaining performance without causing overtraining or fatigue" (p. 155). A competition period lasts for 2-3 months while the complex one for 4-5 months.

- **TRANSITION PHASE**- According to the text mentioned in his book by Bompa Tudor et al. (2009), the transition phase serves as a link between two annual plans. Its major objectives are psychological rest, relaxation, and preparation. This phase should last no longer than six weeks, otherwise, the athlete detrain, visibly losing most of his or her fitness.
- **UNILATERAL STRENGTH ASYMMETRY**- Muscle imbalance can be described as an inequality in the distribution of forces between the agonist and antagonist muscles of a joint. In other words, muscles acting in one direction on a joint are pulling harder than muscles acting on the joint in the opposite direction. This can negatively affect how the joint functions (Nova Physiotherapy, n.d.).

  These are the asymmetries between opposing muscle groups of the same side of the body (agonist/antagonist) (Pavlović et al., 2022).
- **BILATERAL STRENGTH ASYMMETRY**- Interlimb asymmetry (or bilateral difference, bilateral asymmetry), defined as differences between the dominant and non-dominant limb function or performance (Hodges et al., 2011).

SIGNIFICANCE OF STUDY

The study may contribute in the following way:

1. The study will provide insights into muscle imbalances during various phases of sports training.
2. The study will enhance understanding of the impact of detraining on leg strength profiles.
3. The study will provide evidence regarding peak torques values at various speeds of movement.
4. This research will contribute to exercise physiology and sports medicine by exploring the possible avenue for injury risk.
5. Findings will assist coaches in developing strength programs targeting specific muscle groups to prevent injuries.

6. The study may add new knowledge in the field of sports research in general and particularly in the field of basketball. This normative data should be useful for strength and conditioning professionals and physical therapists when interpreting the results of isokinetic leg strength testing and designing and evaluating training and rehabilitation programs for basketball players.
7. The knowledge can aid in team selection processes and talent identification.
8. Given the lack of consensus in existing studies regarding the Hamstring to Quadriceps (H/Q) peak torque ratio and Bilateral Asymmetry in knee injuries, crucial factors such as body weight's significant impact, sparse eccentric data—particularly in female players—and inconsistent use of gravity-corrected data underscore the unreliability of comparisons. Additionally, variability in reporting strength training workouts during training further complicates data interpretation and application. This study will overcome this.
9. The study will help detect regular adaptations to sports versus pathological conditions post-injury.
10. The study emphasizes the importance of lower limb muscle strength measurement in assessing training programs and screening for muscle imbalances, especially related to muscle-tendon injuries and rehabilitation.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Review of available literature is an essential step for the scientific research. A proper review of literature provides basic information about the research problem, its background, the methodologies adopted previously to solve similar research problems, current progress on the subject matter, global trends on the subject, and the future prospects. For the present study, an exhaustive review of related literature was conducted through exploring books, periodicals, magazines, theses/dissertations in the library, over the internet, backward citation searching, and expert discussion. A summary of the review process is presented in this section.

Basketball is a contact sport with complex movements that include jumps, turns and changes in direction, which cause frequent musculoskeletal injuries in all regions of the body. An integrative systematic review of the epidemiology of musculoskeletal injuries in basketball was conducted by **(Andreoli et al. (2018).** The study was based on the following sources of information: PubMed/MEDLINE, Embase, LILACS, BBO-Biblioteca Brasileira de Odontologia, IBECS-Índice Bibliográfico Espanhol em Ciências da Saúde, nursing journals, dental journals and core clinical journals in the last 10 years with studies addressing the general epidemiology of sports injuries in basketball. In total, 268 articles were selected, of which 11 were eligible for the integrative review. A total of 12,960 injuries were observed, most of which occurred in the lower limbs (63.7%), with 2,832 (21.9%) ankle injuries and 2,305 (17.8%) knee injuries. Injuries in the upper limbs represented 12%–14% of the total injuries. Children and adolescents received head injuries more often compared with the other age and skill categories. In the adult category, there was an increased prevalence of injuries in the trunk and spine. In the upper limbs, hands, fingers and wrists were affected more frequently than the shoulders, arms and forearms. In the masters' category, there was an increase in the incidence of thigh injuries. The lower limbs were the most affected, with the ankle and knee joints having the highest prevalence of injuries regardless of gender and category. Further randomised studies, increased surveillance and epidemiological data collection are necessary to improve knowledge on sports injuries in basketball and to validate the effectiveness of preventive interventions.

It is currently unclear how sports participation affects knee-joint muscle balance, which is widely considered a risk factor for hamstrings injury. **Evangelidis et al. (2015)** compared

the angle-specific functional hamstring-to-quadriceps (H:Q) ratio (hamstrings eccentric torque as a ratio of quadriceps concentric torque at the same knee-joint angle) of football players with recreationally active controls. Ten male footballers and 14 controls performed maximal voluntary isometric and isovelocity concentric and eccentric contractions (60, 240 and 400° s^{-1}) of the knee extensors and flexors. Gaussian fitting to the raw torque values was used to interpolate torque values for knee-joint angles of 100–160° (60° s^{-1}), 105–160° (240° s^{-1}) and 115–145° (400° s^{-1}). The angle-specific functional H:Q ratio was calculated from the knee flexors eccentric and knee extensors concentric torque at the same velocity and angle. No differences were found for the angle-specific functional H:Q ratio between groups, at any velocity. Quadriceps and hamstrings strength relative to body mass of footballers and controls was similar for all velocities, except concentric knee flexor strength at 400° s^{-1} (footballers +40%; $P < 0.01$). In previously uninjured football players, there was no intrinsic muscle imbalance and therefore the high rate of hamstring injuries seen in this sport may be due to other risk factors and/or simply regular exposure to a high-risk activity.

Muscle strength imbalances have been linked with poor agility performance and higher injury risk. Isokinetic dynamometry has been used to investigate such imbalances; however, this method is impractical and inaccessible for most strength and conditioning coaches. **Jones & Bampouras (2010)** aimed to compare isokinetic dynamometry with functional field tests for assessing bilateral strength imbalance. Thirteen male athletes from various sports (mean ± SD: age 21 ± 1.1 years, height 179.8 ± 7.0 cm, body mass 80 .8 ± 9.7 kg) participated in the study. Knee flexor and extensor strength at 60 deg·s^{-1} was assessed for both limbs with the use of isokinetic dynamometry. Field tests involved seated unilateral leg press, horizontal hop, single leg vertical and drop jumps. Significant differences ($p<0.01$) were found when comparing strength dominant and non-dominant limbs for all strength measures, ranging from 4.5% (hop test) to 12.4% (eccentric extension). No significant differences between the right and left limbs were found ($p>0.05$). No significant relationships between strength dominant / non-dominant ratios of isokinetic variables and the field tests were evident ($p>0.05$). The findings provide support for the use of field tests to detect imbalances between lower limbs, but the ultimate choice of test used should depend on the specific strength quality that predominates in the sport.

The imbalance of muscle strength indicators is harmful for elite sport and, in case of significant asymmetries, it increases the probability of muscular injuries or the deterioration of

the athletic performance. So, it's essential the evaluation of these imbalances in Handball, Basketball, Soccer and Volleyball athletes.

Another study by **Teixeira et al. (2014)** verified the existence of Isokinetic muscle imbalances in the profile of professional athletes from various modalities and examine their relationship with the sport practiced. Through an observational, analytical and cross study were evaluated 86 athletes (Handball=14; Basketball=27; Football=25; Volleyball=20) using an isokinetic dynamometer Biodex Medical System 4 ®. The evaluated parameters were the Bilateral Differences and Hamstrings/Quadriceps Ratio at angular velocities of 60 °/s (4 repetitions) and 180 °/s (6 repetitions). Results: The Bilateral Differences (found) between the lower limbs are within the respected normal values (<10%). The Hamstrings / Quadriceps Ratio were higher in Football athletes and were lower in Volleyball athletes comparatively to other modalities. However, the motor skills of each sport do not seem to induce to significant muscular imbalances but each sport requires a specific isokinetic profile.

Hamstring injury is one of the most common injuries affecting players in different field sports. Research in various sports on whether residual hamstring weakness is present after hamstring injury is inconsistent.

Many hamstring injuries that occur during physical activity occur while the muscles are lengthening, during eccentric hamstring muscle actions. Opposite of these eccentric hamstring actions are concentric quadriceps actions, where the larger and likely stronger quadriceps straighten the knee. Therefore, to stabilize the lower limbs during movement, the hamstrings must eccentrically combat against the strong knee-straightening torque of the quadriceps. As such, eccentric hamstring strength expressed relative to concentric quadricep strength is commonly referred to as the "functional ratio" as most movements in sports require simultaneous concentric knee extension and eccentric knee flexion. To increase the strength, resiliency, and functional performance of the hamstrings, it is necessary to test and train the hamstrings at different eccentric speeds.

Stastny et al. (2018) provided the instructions for measuring and interpreting eccentric hamstring strength. Techniques for measuring the functional ratio using isokinetic dynamometry are provided and sample data was compared. Additionally, he briefly described

how to address hamstring strength deficiencies or unilateral strength differences using exercises that specifically focus on increasing eccentric hamstring strength.

Isokinetic knee dynamometry evolves towards more precise techniques, such as the calculation of the functional ratio.

Conventionally, the hamstring: quadriceps strength ratio is calculated by dividing the maximal knee flexor (hamstring) moment by the maximal knee extensor (quadriceps) moment measured at identical angular velocity and contraction mode. The agonist-antagonist strength relationship for knee extension and flexion may, however, be better described by the more functional ratios of eccentric hamstring to concentric quadriceps moments (extension), and concentric hamstring to eccentric quadriceps moments (flexion). **Aagaard et al. (1998)** compared functional and conventional isokinetic hamstring: quadriceps strength ratios and examined their relation to knee joint angle and joint angular velocity. Peak and angle-specific (50°, 40°, and 30° of knee flexion) moments were determined during maximal concentric and eccentric muscle contractions (10° to 90° of motion; 30 and 240 deg/sec). Across movement speeds and contraction modes the functional ratios for different moments varied between 0.3 and 1.0 (peak and 50°), 0.4 and 1.1 (40°), and 0.4 and 1.4 (30°). In contrast, conventional hamstring:quadriceps ratios were 0.5 to 0.6 based on peak and 50° moments, 0.6 to 0.7 based on 40° moment, and 0.6 to 0.8 based on 30° moment. The functional hamstring:quadriceps ratio for fast knee extension yielded a 1:1 relationship, which increased with extended knee joint position, indicating a significant capacity of the hamstring muscles to provide dynamic knee joint stability in these conditions. The evaluation of knee joint function by use of isokinetic dynamometry should comprise data on functional and conventional hamstring:quadriceps ratios as well as data on absolute muscle strength.

Rouis et al. (2015) explored the isokinetic concentric strength of the knee muscle groups, and the relationship between the isokinetic knee extensors strength and the vertical jump performance in young elite female basketball players. Eighteen elite female basketball players performed a countermovement jump, and an isokinetic knee test using a Biodex dynamometer. The maximal isokinetic peak torque of the knee extensor and flexor muscles

was recorded at four angular velocities (90°s^{-1}, 180°s^{-1}, 240°s^{-1} and 300°s^{-1}) for the dominant and non-dominant legs. The conventional hamstring/quadriceps ratio (H/Q) was assessed at each angular velocity for both legs. There was no significant difference between dominant and non-dominant leg whatever the angular velocity (all $p > 0.05$). However, the H/Q ratio enhanced as the velocity increased from 180°s^{-1} to 300°s^{-1} ($p < 0.05$). Furthermore, low to high significant positive correlations were detected between the isokinetic measures of the knee extensors and the vertical jump height. The highest one was found for the knee extensors peak torque at a velocity of 240°s^{-1} ($r = 0.88$, $p < 0.001$). The results accounted for an optimal velocity at which a strong relationship could be obtained between isokinetic knee extensors strength and vertical jump height. Interestingly, the H/Q ratio of the young elite female basketball players in the present study was unusual as it was close to that generally observed in regular sportsmen.

A study by **Theoharopoulos et al. (2000)** aimed to assess the impact of rigorous and systematic training on the lower-extremity strength of professional basketball players, focusing on knee extension and flexion concentric strength across a full range of motion. Conducted using an isokinetic dynamometer at velocities of 60 and 180°$\cdot s^{-1}$, the research involved 12 male basketball players from the same professional team, representing various playing positions.

Interfacing of microprocessors with isokinetic dynamometers has enabled the rapid quantification of many parameters of muscle function including peak torque, angle-specific torque, work, power, torque acceleration energy, and various endurance indexes, and the measurements with these devices can be made isometrically at various angular positions and isokinetically (concentrically or eccentrically) with a large scale of angular speeds.

Many of these parameters, however, lack evidence of validity, reproducibility, and/or clinical relevance. Peak torque has been and still is the most properly studied isokinetic strength testing parameter and its use can be recommended for research and clinical purposes. Concerning testing of muscular endurance, the absolute endurance parameters (for example, work performed during the last five repetitions and total work in a 25-repetition test with a speed of 240°/s) are the best for use.

Many internal and external factors in the isokinetic testing procedure can have an undesirable effect on the test result. However, through proper education and strict adherence to the test Instructions, it is possible to successfully control the confounding variables.

In scientific work, isokinetic devices have greatly expanded the possibilities for studying dynamic muscle function. There is also little doubt about their usefulness in documenting the progress of muscular rehabilitation.

A disadvantage of isokinetic devices is that isokinetic movement seldom occurs in actual human Performance tasks and that the isokinetic training effect is, therefore, quite (although not completely) specific to that type of movement. In addition, being normally an isolated Joint exercise, isokinetic training can produce large loads on the involved joints and may, therefore, under certain conditions be dangerous for healing tissues. (**Kannus, 1994)**

Systematic assessment of muscle strength of the lower extremities throughout the annual training cycle in athletes is crucial from a performance perspective for the optimization of the training process, as well as a health perspective with regard to injury prevention. The main aim of the study by **Xaverova et al. (2015)** was to determine isokinetic muscle strength of the knee flexors and extensors in female handball players at the beginning of a preparatory period and to assess whether there were any differences between players of different performance levels. The performance level was expressed by means of membership of the Women's Junior National Handball Team (JNT, n=8) or the Women's National Handball Team (NT, n=9). The isokinetic peak torque during concentric and eccentric single-joint knee flexion and extension was measured at angular velocities of 60, 180, 240°/s (concentric) and 60°/s (eccentric). The Mann Whitney test showed no significant differences in the peak torques or ipsilateral ratios between the two groups. The bilateral force deficit (BFD) for concentric extension at 240°/s was significantly higher in the JNT compared with the NT ($p=0.04$; $d=1.02$). However, the results of individual evaluation show that the BFD was more frequent in the NT in most measurements. A high BFD was evident in the eccentric mode in both groups highlighting a need for particular strengthening. With regard to low strength ratios a prevention programme should be suggested for both observed groups of professional female handball players to reduce the risk of injury.

Abad et al. (2022) aimed to examine the changes that occurred in vertical jump and isokinetic dynamometer (ISK) performances at the beginning of a preparatory period (PRE) and at the start of the competitive period (POST). Sixteen U-17 elite female volleyball players, from a national level (15.34 ± 1.19 years; 66.35 ± 7.95 kg; 169.22 ± 24.79 cm), performed bilateral squat jump (SJ), bilateral and unilateral countermovement jump (CMJ) and unilateral ISK tests for knee flexors (Fl) and extensors (Ex) both at 60˚/s and at 300˚/s. Peak torque (PT) and the hamstring-to-quadriceps (H:Q) ratio were assessed by concentric actions. Asymmetries were calculated by the percentage differences between dominant (DOM) and nondominant legs (NDOM). The paired Student's t-test was used for comparisons at a level of significance of 5%. The effect size was also calculated. A significant increase was found for both SJ (15%; p = 0.004; ES = 0.82) and CMJ (12%; p = 0.017; ES = 0.62). The PT of NDOM flexors at 60˚/s was significantly lower than DOM both at PRE (4.6%; p = 0.048; ES = −0.22) and POST (6.3%; p = 0.037; ES = −0.33). The NDOM extensors at 60˚/s had a significantly lower PT than DOM at POST (7.0%; p = 0.048; ES = −0.23). Both DOM and NDOM flexors at 60˚/s had a PT enhancement at POST related to PRE (6.7%; p = 0.031; ES = 0.51 and 5.6%; p = 0.037; ES = 0.48, respectively). The PT of NDOM extensors at 300˚/s increased at POST in comparison to PRE (7.9%; p = 0.038; ES = 0.27). The NDOM at 300˚/s had a H:Q ratio higher than DOM both in PRE and POST (8.6%; p = 0.041; ES = 0.37 and 11.6%; p = 0.013; ES = 0.71, respectively), and the highest H:Q ratios were lower than the reference values (<80%). The asymmetry of the unilateral CMJ was higher at POST than at PRE (102%; p = 0.03; ES = 0.81). The PT for the flexors at 300˚/s and the H:Q ratio at POST exceeded 10%. In conclusion, a training program of 15 weeks increased the neuromuscular performance of young volleyball athletes, but many H:Q ratios and asymmetries remained out of the normal recommendation. Professionals should carefully apply an adequate training program to enhance physical fitness performance without increasing the risk of lower limb injuries concurrently.

Detraining is partial or complete loss of training induced anatomical, physiological and performance adaptations, as a consequence of training reduction or cessation. Detraining characteristics may be different depending on the duration of training cessation or insufficient training. It may be short term detraining (less than 4 weeks of insufficient training stimulus) or long-term detraining (more than 4 weeks of insufficient training stimulus). According to the principle of reversibility, training induced physiological adaptations are transitory and may

disappear when the training load is not sufficient. The reasons for such a scenario are numerous in an athlete's life: illness, injury, post-season break or training load adaptation to recover from a state of overreaching. **Bosquet & Mujika (2012)** performed a meta-analysis to examine the effect of training cessation on maximal force and maximal power and found that both neuromuscular qualities could be maintained for up to 3-4 weeks before declining. At the muscle level, capillary density and oxidative enzyme activities are reduced. Training-induced changes in fibre cross-sectional area are reversed, but strength performance declines are limited in short term.

Mujika & Padilla (2000) discusses detraining following an insufficient training stimulus period longer than 4 weeks, as well as several strategies that may be useful to avoid its negative impact. The maximal oxygen uptake ($\dot{V}_{O2max}$) of athletes declines markedly but remains above control values during long term detraining, whereas recently acquired $\dot{V}_{O2max}$ gains are completely lost. This is partly due to reduced blood volume, cardiac dimensions and ventilatory efficiency, resulting in lower stroke volume and cardiac output, despite increased heart rates. Endurance performance is accordingly impaired. Resting muscle glycogen levels return to baseline, carbohydrate utilisation increases and the lactate threshold is lowered, although it remains above untrained values in the highly trained. At the muscle level, capillarisation, arterial-venous oxygen difference and oxidative enzyme activities decline in athletes and are completely reversed in recently trained individuals, contributing significantly to the long-term loss in $\dot{V}_{O2max}$. Oxidative fibre proportion is decreased in endurance athletes, whereas it increases in strength athletes, whose fibre areas are significantly reduced. Force production declines slowly, and usually remains above control values for very long periods. All these negative effects can be avoided or limited by reduced training strategies, as long as training intensity is maintained and frequency reduced only moderately. On the other hand, training volume can be markedly reduced. Cross-training may also be effective in maintaining training-induced adaptations. Athletes should use similar-mode exercise, but moderately trained individuals could also benefit from dissimilar-mode cross-training. Finally, the existence of a cross-transfer effect between ipsilateral and contralateral limbs should be considered in order to limit detraining during periods of unilateral immobilisation.

Covid-19 pandemic has dramatically affected football, one of the most popular sports in the world, and significantly changed the competitive sports sphere. The study by **Koç (2021)** was conducted to examine the effects of the suspensions and isolation process applied in

leagues due to Covid-19 on the performance levels of amateur football players. Twenty male amateur football players (19.05±1.3 years) participated in the study as volunteers. Certain physical tests were applied to examine participants' performance levels. The detraining period was 80 days. Pre-testing started in March 2020 when the restrictions first introduced in Turkey as the post-test process was initialized in the first week of June after normalization signals. Results showed that there are statistically significant variances in the parameters of body weight, body mass index, sit-and-reach, hand grip strength, medicine ball throw, 30-m speed, Illinois agility, 30-sec sit-ups, 30-sec push-ups, counter movement jump, peak power, Yo-Yo IR-Level 1 and $\dot{V}_{O2max}$ ($p<0.05$). It was concluded that the performance levels of amateur football players deteriorated significantly during the detraining period due to the pandemic.

The Coronavirus disease (COVID-19 outbreak had become the chief health concern all over the world. This universal epidemic with high morbidity and mortality rate affected the sports world as well as other fields of human life. In this situation, the routine and professional training of soccer players had been cancelled. Alterations in the training features including frequency, volume, and intensity resulted in fitness detraining which definitely had unpleasant effects on their professional life, including alterations in their physiological traits and performance.

The purpose of the study by **Nakisa & Ghasemzadeh Rahbardar (2021)** was to shed light on the probable effects of the COVID-19 epidemic detraining on athletes, in order to persuade coaches and athletes to pay more attention to detraining unpleasant effects and make appropriate decisions, and employ effective strategies to reduce and prevent these effects and return to full fitness.

The main purpose of the article by **Ziv & Lidor (2010)** was to review a series of studies (n = 26; 15 observational and 11 experimental) examining vertical jump (VJ) performances in female and male basketball players. Information on the tests used in these studies and their specific protocols, and the training programs conducted to improve VJ ability in elite basketball players, was assessed. It was found that vertical jump values varied greatly, from 22 to 48 cm in female players and from 40 to 75 cm in male players. These large variations can be explained mostly by the differences in testing protocols (each VJ protocol examined different physiological pathways) and skill level of players. The variations in VJ values among studies

were greatly reduced when they used the same protocol. In addition, short plyometric training sessions as part of the strength and conditioning program were found to enhance VJ performances in basketball players. Based on the reviewed studies, five limitations associated with the testing protocols and the strength and conditioning programs used in the studies were outlined, among them the use of multiple testing protocols and lack of experimental studies. Three recommendations for basketball and strength and conditioning coaches were suggested, for one of which was including plyometric training in the annual training program.

CHAPTER 3
METHODOLOGY AND PROCEDURE

In this part of investigation, the tools that will be used to gather the information or data, as well as the procedure that will be adopted to deal with the data, are presented in an appropriate manner.

The following subheadings have been presented for the research methodology that has to be adopted:

1. Selection of Sample
2. Selection of Variables
3. Criterion Measure
4. Training Program
5. Data Collection
6. Administration of Test
7. Statistical Techniques

Selection of Sample

As per the objective of the study, a total of 24 basketball players (12 male and 12 female) belonging to Lakshmibai National Institute of Physical Education, Gwalior will be selected purposively in the present study.

Inclusion criteria for recruitment of basketball players in this study:

i. Athletes who practise basketball sports for at least five years
ii. Age between 18 and 26 years
iii. The main inclusion criteria for further analysis will be that players have to play in the All India Inter University basketball team.

Any subject who shows the below mentioned symptoms will not be considered for the study:

i. any injury in the moment of the assessment (pain, swelling and inflammation) (Lund et al., 2005);

ii. History of surgery and instability on the lower limbs at the time of testing or during six months before testing. (Buchanan & Vardaxis, 2003; Carvalho et al., 2011);
iii. pain sensation during the isokinetic assessment (Lund et al., 2005);
iv. any limitation that could affect the performance or the measurements during the study (Buchanan & Vardaxis, 2003).

All the participants will be informed regarding the objectives of the study before the collection of data and they will give their consent. All athletes will go thorough clinical evaluation for knee injuries in the health centre of Lakshmibai National Institute of Physical Education, Gwalior.

Selection of Variables

Literature reviews, expert opinions, scholar's own understanding and administrative feasibility of instruments are weighed on the nature of research problem while keeping in mind the importance and the rapid use of these movements in basketball game:

1. Knee Flexion
2. Knee Extension

Following independent and dependent variables are selected for study by the scholar:

Table 3.2: Selected Variables for the present study

Independent Variable		Dependent Variable
Phases of training	Detraining	
	Competition	Peak Torque Values
	Transition	Peak Torque to Body Weight Ratio
Speed of Movement	$60°\cdot s^{-1}$	Unilateral Conventional Ratio
	$120°\cdot s^{-1}$	Unilateral Functional Ratio
	$180°\cdot s^{-1}$	Bilateral Asymmetry Percentage
Mode of Movement	Concentric	
	Eccentric	

Criterion Measure

The following criterion measures are implemented in the current investigation, which is presented in below:

Table 3.3 Selected variables with their criterion measure and unit of measurement

S. No.	Variable	Criterion Measure	Unit of Measurement
1	Peak Torque Value	Isokinetic Dynamometer	Newton-Meters
2	Peak Torque to Body Weight	Isokinetic Dynamometer	-
3	Unilateral Conventional Ratio	Concentric H/Q ratio	-
4	Unilateral Functional Ratio	Hecc/Qconc ratio – the dynamic control ratio –DCR	-
5	Bilateral Asymmetry Percentage	[1- (PT left/PT right)] ×100 (Hadzic et al., 2010)	%

Data Collection

In order to measure knee flexor/extensor muscular strength, CSMI or Cybex Norm Isokinetics machine and Humac 2009 software will be used. This machine facilitates testing at any given angle and speed for any group of muscle. It has a special feature of correcting the effects of gravity which is necessary for error free data. The Humac Norm Testing and Rehabilitation system has a positioning chair which assures complete stability during testing and have independent adjustable seats. It has dynamometer with integral limit device providing controlled testing. The dynamometer's rotation, height and tilt can be changed to properly position it for the testing or rehabilitation pattern being used. The computer attached to the machine acts as the testing procedure memory which records data during test and simultaneously displays the data in the form of graphs. The isokinetic dynamometer (Computer

Sports Medicine, inc, 101 Tosca Drive, Stoughton, MA 02072) will be used for the assessment of the variables (Peak Torque and Peak Torque to Body Weight) which is tested and validated for the quantitative mechanical assessment of muscular performance, showing also high reliability. Regarding the anthropometric measurements, to assess the body mass the digital scale Tanita Professional Digital Physician Scale WB-100 (Tanita established in Tokyo, Japan) will be used. Moreover, to measure height stadiometer Seca 214® (Seca, established in Vila Verde, Sintra, Portugal) will be used.

Figure 3.1 CSMi Isokinetic Dynamometer and Humac Software

Reliability of Data

Reliability of data will be ensured by establishing the instrument reliability and tester reliability.

- **Instrument reliability**

To measure the reliability of the HUMAC NORMS System, dynamometer will be calibrated prior to the start of the study according to the operating manual by using weight plates for every movement selected, before using it for testing and thus ensuring the reliability. The instrument is obtained from standard firm which cater to the needs of various research laboratory in India and abroad. Instrument to be used in the study is available in research laboratory of Lakshmibai National Institute of Physical Education, Gwalior. The machine has high test-retest reliability of 0.82-0.91 in case of peak torque measurements (Delextrat A et al., 2008; Li RC et al., 1996; Zakas et al., 1995; Gerodimos V et al., 2003).

- **Tester reliability**

To ensure that the scholar is well versed with the technique of conducting the tests, the scholar will have a number of practice sessions in testing procedure under the supervision of experts and guides. Proper instruction will also be given to the assistants before the administration of the tests.

Test Administration

The test for the measurement of the mentioned variables, will be conducted at the laboratory of Department of Exercise Physiology, Lakshmibai National Institute of Physical Education, Gwalior. Subjects will be instructed not to eat for at least 3 hours and not to drink coffee or beverages containing caffeine for at least 8 hours before each testing session. Subjects will wear similar clothing and the same footwear on each testing occasion (Carvalho et al., 2011). They will b asked not to perform intense exercise on the day prior to a test.

Initially, body mass and body height will be measured. Then the participants will execute a warm-up comprising stretching exercise, 10-15 min of moderate running and 3-4 short sprints followed by general mobility exercises (lunges, squats, calf raise, crab walk) and sport-specific movements (changes of direction, jumps, shuffles).

Knee extension/flexion strength will be measured on CSMI or Cybex Norm isokinetic dynamometer. The basic information of the subject will be entered in the computer and according to this the computer will provide the perfect setting for that particular subject. All the subjects will be instructed about the basic functioning of machine and the sequence in which different test items to be conducted.

The scores will be recorded in the software in the form of peak torque and peak torque to body weight ratio. The result will appear on the monitor of the machine. The peak torque (PT) expressed in Newton meters ($N \cdot m^{-1}$) and peak torque to body weight ratio (PTBW) will be assessed concentrically and eccentrically for both knee extensor and flexor muscles in both the left and right legs at 60 deg/sec, 120 deg/sec and 180 deg/sec. This speed is chosen as it is within the range of angular velocities commonly used to assess knee extensor and flexor strength in basketball players (Alemdaroğlu, 2012; Delextrat & Cohen, 2009).

Muscular Imbalance and Asymmetries

Muscle strength imbalances will be obtained through the conventional and the functional Hamstring to Quadriceps ratio and for muscle asymmetries, calculation of bilateral deficit between limbs will be done.

To assess muscular imbalances in the knees, H:Q ratio will be assessed (Aagaard et al., 1995) as-

$$\mathbf{H:Q_{Conv} = (H_{conc}/Q_{conc})}$$

Here, H= Hamstring group of muscles/ Knee Flexors

Q= Quadriceps group of muscles/ Knee Extensors

Conc= Concentric

and functional H:Q ratio will be assessed (Aagaard et al., 1998) as-

$$\mathbf{H:Q_{Func} = (H_{ecc}/Q_{ecc})}$$

Here, H= Hamstring group of muscles/ Knee Flexors

Q= Quadriceps group of muscles/ Knee Extensors

Conc= Concentric

Ecc= Eccentric

The bilateral asymmetries (contralateral deficit) will b obtained using the Limb Symmetry Index mentioned by (Schiltz et al., 2009; Hadzic et al., 2013) by calculating the percentage differences between dominant and non-dominant limbs as-

$$\mathbf{LSI = [(1- NDL/DL) \times 100] \%}$$

Here, DL= Dominant Limb=Left Limb

NDL= Non-Dominant Limb=Right Limb

Statistical Techniques

Data of all the phases at different velocities will be collected and analysed with the help of SPSS. The level of significance is set at 0.05 level, and the statistical analyses will be carried out in the following manner:

- Descriptive Statistics (Mean and Standard Deviation), along with graphical representation will b presented for all the variables in different phases at different velocities.
- The assumption of normality of data will be tested using Shapiro-Wilk test. The insignificance of Shapiro-Wilk test referred to normality of data, and hence further statistical tests will be applied.
- Independent t-test will be used to compare the different selected variables between male and female subjects.
- One-way Repeated Measure ANOVA will be used to compare the different selected variables in different phases and at different velocities.

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